

flash of movement caught my eye. If the lizard had stayed still, I might have stepped on it: its color perfectly matched the dazzling expanse of white sand. Good thing, I thought, that rattlesnakes here in south-central New Mexico aren't white too. Three different species of white lizards can be spotted on the dunes from May through September. That is, if you're looking for them.

I was standing on the world's largest gypsum dune field, at White Sands National Monument, where I have worked as a biologist and land manager for nine years. Looking up from my feet, I gazed out across a sea of snow-white dunes to a rugged skyline of bare limestone mountains. The dune field covers an area of 275 square miles, about half of which is open to the public and managed by the National Park Service. The other half is military land, shared by a missile range and Holloman Air

Force Base. Recent findings indicate the dunes formed within the past 7,000 years—a geological blink of the eye. And that gives a useful time frame for the rapid evolution of lizards, like the one I saw skittering across the sand.

Other creatures that, like the lizards, are small and easily preved upon, have also tended toward lighter colors. With a permanent change of coloration, they can improve concealment on the gypsum dunes and thereby improve their chances of survival, as well as their chances of producing future generations that will inherit the advantage. You can see this on a short stroll from a park road in New Mexico

Typsum is the stuff of plaster and drywall: a common mineral also known as hydrated calcium sulfate. Why then have some 8 billion tons of it collected in a series of dunes up to forty feet tall? The "white sand" of White Sands had its distant origin when marine deposits were left by an evaporating shallow sea in the Permian period, 250 million years ago. Some of those deposits were uplifted about 10 million years ago into mountain ranges that ring an area known today as the Tularosa Basin. Water leached gypsum out of those mountains and carried the dissolved mineral down into the Basin, where a large saline lake formed during the cooler and wetter times of the Pleistocene, within the past 2 million years.

The environment ultimately changed about 10,000 years ago to arid desert: the lake dried up, and mineral residue was left on the valley floor, forming crystalline gypsum. The same process continues today to a lesser extent, with mineralized groundwater reaching the valley floor, drying, forming gyp-



sum, and blowing away to further expand the dune field.

Deposits of pure crystal gypsum are unusual because the substance is water-soluble: streams or rivers carry most of it away. But the Tularosa Basin has no surface outlet. Strong spring winds scour out the valleyfloor gypsum deposits and move them downwind to where the dunes formed as wind velocity abated. The dunes are still very much on the move: frequent plowing is required every windy spring to keep the national monument's dune road open, just as snow is plowed in colder areas.

In 2006, a geological team from the University of Texas at Austin and the Physical Research Laboratory of Navrangpura, India, determined a precise date for the formation of White Sands. In a core-sampling project, the team drilled down through the gypsum and collected lakebed sediment samples from directly beneath the white sand. Carbon material in the topmost lake sediment was dated to 7,000 years before the present. That date marks the drastic environmental change from lake to desiccated dune field.

/nowing when the sand dunes began to accumulate tells us when

animals could have begun to adapt to living in a white environment. Between the 1920s and the 1960s, biologists documented seven animal species that had permanently white coloration on the gypsum dunes, with darker forms living nearby in the desert off the dunes: three lizard species, the Apache pocket mouse, the White Sands woodrat (a subspecies of the southern plains woodrat), and two species of camel cricket. With lizards, rodents, and insects making a color change in a few thousand years, something evolutionary was definitely happening.

In the last decade, interest has grown in using White Sands as a natural laboratory—it is a regular desert Galápagos. Stephen B. Hager made the first detailed study of the lizard species at White Sands for his Ph.D. at New Mexico State University, investigating color differences and temperature regulation of lizards on and off the dunes. Erica Bree Rosenblum, with the University of California at Berkelev at the time, next set out to understand differences among populations in an evolutionary context. Rosenblum quantified the gradient from light to dark in lizards of three different species. She verified that white lizards have white offspring, indicating that color at White Sands is an inherited trait. Furthermore, Rosenblum and her collaborators identified a single gene that seems to be responsible for light coloration in White Sands lizards. This was an exciting find, given that identifying the genetic basis of an adaptive trait is still rare.

Rosenblum's experiments on mate selection also told an interesting story. In lab tests, white males of the lesser earless lizard (Holbrookia maculata) distinctly preferred white females to brown females. Although brown and white forms of the lesser earless lizard are currently considered the same species, they may be in the early stages of speciation.

Natural selection can act as a strong force in such areas of transition from one ecosystem to another, or "ecotones." Conditions are considerably different on the gypsum dunes than off them. Not only background colors contrast starkly, but also the types of plants found there and how densely they grow. That, in turn, influences the lizards' prev and predators. Such differences can drive rapid speciation, particularly if coupled with a preference for local mates, which

Bottom left: Two little striped whiptails (Aspidoscelis inornata) on white gypsum sand at White Sands National Monument. Bottom right: Two white lesser earless lizards (Holbrookia maculata), both females in "breeding colors," on the white sand. The darker lizards of both species were captured from a darker habitat adjacent to the dunes.







can enforce genetic separation even without the geographic separation imposed by islands or mountaintops. White Sands is its own oasis for rapid evolution.

resident Herbert Hoover established White Sands National Monument in 1933, proclaiming that his reason for doing so was to preserve "the white sands and additional features of scenic, scientific, and educational interest." There was little scientific understanding of the area at that time. Yet preservation for the sake of science and future discoveries was a noble cause then, and should be considered an equally noble cause now.

The scenic beauty of the expansive white sand dunes will always draw visitors for inspiration and recreation, but strong evolutionary pressure in a changing environment may be the most important scientific attraction at White Sands National Monument. The lightcolored species and how they came to be that way could become a textbook example of rapid evolution. Who knows? Maybe the rattlesnakes will be next.

WILLIAM CONROD recently retired after thirty-two years with the National Park Service, includi ng nine years at White Sands National Monument as the park biologist and natural resource manager. ERICA BREE ROSENBLUM received her Ph.D. from the University of California at Berkeley, and is currently an assistant professor of biology at the University of Idaho. Her research at White Sands continues.